Quark and Lepton Compositeness, Searches for

NODE=S054

The latest unpublished results are described in the "Quark and Lepton Compositeness" review. NODE=S054

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NODE=S054CNT
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SCALE LIMITS for Contact Interactions: $\Lambda(eeee)$

NODE=S054CTE

Limits are for $\Lambda^{\pm}_{LL}$ only. For other cases, see each reference. NODE=S054CTE

NODE=S054CTE

Λ^{+}_{LL}(TeV)	Λ^{-}_{LL}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>8.3	**>10.3**	95	[1] BOURILKOV	01	RVUE	E_{cm}= 192–208 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>4.5	>7.0	95	[2] SCHAEL	07A	ALEP	E_{cm}= 189–209 GeV
>5.3	>6.8	95	ABDALLAH	06C	DLPH	E_{cm}= 130–207 GeV
>4.7	>6.1	95	[3] ABBIENDI	04G	OPAL	E_{cm}= 130–207 GeV
>4.4	>5.4	95	ABREU	00S	DLPH	E_{cm}= 183–189 GeV
>4.3	>4.9	95	ACCIARRI	00P	L3	E_{cm}= 130–189 GeV

[1] A combined analysis of the data from ALEPH, DELPHI, L3, and OPAL. NODE=S054CTE;LINKAGE=BT

[2] SCHAEL 07A limits are from R_c, Q^{depl}_{FB}, and hadronic cross section measurements. NODE=S054CTE;LINKAGE=SE

[3] ABBIENDI 04G limits are from $e^+e^- \to e^+e^-$ cross section at $\sqrt{s}$ = 130–207 GeV. NODE=S054CTE;LINKAGE=AB

SCALE LIMITS for Contact Interactions: $\Lambda(ee\mu\mu)$

NODE=S054CTM

Limits are for $\Lambda^{\pm}_{LL}$ only. For other cases, see each reference. NODE=S054CTM

NODE=S054CTM

Λ^{+}_{LL}(TeV)	Λ^{-}_{LL}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>6.6	**>9.5**	95	[4] SCHAEL	07A	ALEP	E_{cm}= 189–209 GeV
> 8.5	>3.8	95	ACCIARRI	00P	L3	E_{cm}= 130–189 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

>7.3	>7.6	95	ABDALLAH	06C	DLPH	E_{cm}= 130–207 GeV
>8.1	>7.3	95	[5] ABBIENDI	04G	OPAL	E_{cm}= 130–207 GeV
>6.6	>6.3	95	ABREU	00S	DLPH	E_{cm}= 183–189 GeV

[4] SCHAEL 07A limits are from R_c, Q_{FB}^{depl}, and hadronic cross section measurements. NODE=S054CTM;LINKAGE=SE

[5] ABBIENDI 04G limits are from $e^+ e^- \rightarrow \mu\mu$ cross section at $\sqrt{s}$ = 130–207 GeV. NODE=S054CTM;LINKAGE=AB

SCALE LIMITS for Contact Interactions: Λ($ee\tau\tau$)

NODE=S054CTT

Limits are for $\Lambda_{LL}^{\pm}$ only. For other cases, see each reference.

NODE=S054CTT
NODE=S054CTT

Λ_{LL}^{+}(TeV)	Λ_{LL}^{-}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>7.9	>5.8	95	[6] SCHAEL	07A	ALEP	E_{cm}= 189–209 GeV
>7.9	>4.6	95	ABDALLAH	06C	DLPH	E_{cm}= 130–207 GeV
>4.9	**>7.2**	95	[7] ABBIENDI	04G	OPAL	E_{cm}= 130–207 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>5.2	>5.4	95	ABREU	00S	DLPH	E_{cm}= 183–189 GeV
>5.4	>4.7	95	ACCIARRI	00P	L3	E_{cm}= 130–189 GeV

[6] SCHAEL 07A limits are from R_c, Q_{FB}^{depl}, and hadronic cross section measurements. NODE=S054CTT;LINKAGE=SE

[7] ABBIENDI 04G limits are from $e^+ e^- \rightarrow \tau\tau$ cross section at $\sqrt{s}$ = 130–207 GeV. NODE=S054CTT;LINKAGE=AB

SCALE LIMITS for Contact Interactions: Λ($\ell\ell\ell\ell$)

NODE=S054CTL

Lepton universality assumed. Limits are for $\Lambda_{LL}^{\pm}$ only. For other cases, see each reference.

NODE=S054CTL
NODE=S054CTL

Λ_{LL}^{+}(TeV)	Λ_{LL}^{-}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>7.9	**> 10.3**	95	[8] SCHAEL	07A	ALEP	E_{cm}= 189–209 GeV
>9.1	>8.2	95	ABDALLAH	06C	DLPH	E_{cm}= 130–207 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>7.7	>9.5	95	[9] ABBIENDI	04G	OPAL	E_{cm}= 130–207 GeV
			[10] BABICH	03	RVUE	
>9.0	>5.2	95	ACCIARRI	00P	L3	E_{cm}= 130–189 GeV

[8] SCHAEL 07A limits are from R_c, Q_{FB}^{depl}, and hadronic cross section measurements. NODE=S054CTL;LINKAGE=SE

[9] ABBIENDI 04G limits are from $e^+ e^- \rightarrow \ell^+ \ell^-$ cross section at $\sqrt{s}$ = 130–207 GeV. NODE=S054CTL;LINKAGE=AB

[10] BABICH 03 obtain a bound -0.175 TeV^{-2} <1/Λ_{LL}^2 < 0.095 TeV^{-2} (95%CL) in a model independent analysis allowing all of Λ_{LL}, Λ_{LR}, Λ_{RL}, Λ_{RR} to coexist. NODE=S054CTL;LINKAGE=HB

SCALE LIMITS for Contact Interactions: Λ($eeqq$)

NODE=S054CTH

Limits are for $\Lambda_{LL}^{\pm}$ only. For other cases, see each reference.

NODE=S054CTH
NODE=S054CTH;CHECK LIMITS

Λ_{LL}^{+}(TeV)	Λ_{LL}^{-}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT	
> 9.5	**>12.1**	95	[11] AAD	13E	ATLS	($eeqq$)	
> **10.1**	>9.4	95	[12] AAD	12AB	ATLS	($eeqq$)	
> 8.4	**>10.2**	95	[13] ABDALLAH	09	DLPH	($eebb$)	
> 9.4	**>5.6**	95	[14] SCHAEL	07A	ALEP	($eecc$)	
> 9.4	>4.9	95	[13] SCHAEL	07A	ALEP	($eebb$)	OCCUR=2
>23.3	**>12.5**	95	[15] CHEUNG	01B	RVUE	($eeuu$)	
>11.1	**>26.4**	95	[15] CHEUNG	01B	RVUE	($eedd$)	OCCUR=2
• • • We do not use the following data for averages, fits, limits, etc. • • •							
> 4.2	>4.0	95	[16] AARON	11C	H1	($eeqq$)	
> 3.8	>3.8	95	[17] ABDALLAH	11	DLPH	($eetc$)	
>12.9	>7.2	95	[18] SCHAEL	07A	ALEP	($eeqq$)	OCCUR=3
> 3.7	>5.9	95	[19] ABULENCIA	06L	CDF	($eeqq$)	

[11] AAD 13E limis are from $e^+ e^-$ mass distribution in pp collisions at E_{cm} = 7 TeV. NODE=S054CTH;LINKAGE=I

[12] AAD 12AB limis are from $e^+ e^-$ mass distribution in pp collisions at E_{cm} = 7 TeV. NODE=S054CTH;LINKAGE=G

[13] ABDALLAH 09 and SCHAEL 07A limits are from R_b, A_{FB}^b. NODE=S054CTH;LINKAGE=AL

[14] SCHAEL 07A limits are from R_c, Q_{FB}^{depl}, and hadronic cross section measurements. NODE=S054CTH;LINKAGE=SE

[15] CHEUNG 01B is an update of BARGER 98E. NODE=S054CTH;LINKAGE=BC

[16] AARON 11C limits are from Q^2 spectrum measurements of $e^{\pm} p \rightarrow e^{\pm} X$. NODE=S054CTH;LINKAGE=RO

[17] ABDALLAH 11 limit is from $e^+ e^- \rightarrow t\bar{c}$ cross section. $\Lambda_{LL} = \Lambda_{LR} = \Lambda_{RL} = \Lambda_{RR}$ is assumed. NODE=S054CTH;LINKAGE=AA

[18] SCHAEL 07A limit assumes quark flavor universality of the contact interactions. NODE=S054CTH;LINKAGE=CE

[19] ABULENCIA 06L limits are from $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV. NODE=S054CTH;LINKAGE=AI

SCALE LIMITS for Contact Interactions: $\Lambda(\mu\mu q q)$

NODE=S054CTS
NODE=S054CTS

Λ^{+}_{LL}(TeV)	Λ^{-}_{LL}(TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>9.6	>12.9	95	[20] AAD	13E	ATLS	$(\mu\mu q q)$ (isosinglet)
>9.5	**> 13.1**	95	[21] CHATRCHYAN	13K	CMS	$(\mu\mu q q)$ (isosinglet)
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>8.0	>7.0	95	[22] AAD	12AB	ATLS	$(\mu\mu q q)$ (isosinglet)
>4.5	>4.9	95	[23] AAD	11E	ATLS	$(\mu\mu q q)$ (isosinglet)
>2.9	>4.2	95	[24] ABE	97T	CDF	$(\mu\mu q q)$ (isosinglet)

[20] AAD 13E limis are from $\mu^+\mu^-$ mass distribution in pp collisions at $E_{cm} = 7$ TeV. NODE=S054CTS;LINKAGE=B

[21] CHATRCHYAN 13K limis are from $\mu^+\mu^-$ mass distribution in pp collisions at $E_{cm} =$ 7 TeV. NODE=S054CTS;LINKAGE=C

[22] AAD 12AB limis are from $\mu^+\mu^-$ mass distribution in pp collisions at $E_{cm} = 7$ TeV. NODE=S054CTS;LINKAGE=A

[23] AAD 11E limits are from $\mu^+\mu^-$ mass distribution in pp collisions at $E_{cm} = 7$ TeV. NODE=S054CTS;LINKAGE=AA

[24] ABE 97T limits are from $\mu^+\mu^-$ mass distribution in $\overline{p}p \rightarrow \mu^+\mu^- X$ at E_{cm}=1.8 TeV. NODE=S054CTS;LINKAGE=AT

SCALE LIMITS for Contact Interactions: $\Lambda(\ell\nu\ell\nu)$

NODE=S054CTN
NODE=S054CTN

VALUE (TeV)	CL%	DOCUMENT ID		TECN	COMMENT	
>3.10	90	[25] JODIDIO	86	SPEC	$\Lambda^{\pm}_{LR}(\nu_\mu \nu_e \mu e)$	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
>3.8		[26] DIAZCRUZ	94	RVUE	$\Lambda^{+}_{LL}(\tau\nu_\tau e \nu_e)$	
>8.1		[26] DIAZCRUZ	94	RVUE	$\Lambda^{-}_{LL}(\tau\nu_\tau e \nu_e)$	OCCUR=2
>4.1		[27] DIAZCRUZ	94	RVUE	$\Lambda^{+}_{LL}(\tau\nu_\tau \mu \nu_\mu)$	OCCUR=3
>6.5		[27] DIAZCRUZ	94	RVUE	$\Lambda^{-}_{LL}(\tau\nu_\tau \mu \nu_\mu)$	OCCUR=4

[25] JODIDIO 86 limit is from $\mu^+ \rightarrow \overline{\nu}_\mu e^+ \nu_e$. Chirality invariant interactions $L = (g^2/\Lambda^2)$ $[\eta_{LL}\ (\overline{\nu}_{\mu L}\gamma^\alpha \mu_L)\ (\overline{e}_L \gamma_\alpha \nu_{eL}) + \eta_{LR}\ (\overline{\nu}_{\mu L}\gamma^\alpha \nu_{eL}\ (\overline{e}_R \gamma_\alpha \mu_R)]$ with $g^2/4\pi = 1$ and $(\eta_{LL},\eta_{LR}) = (0,\pm1)$ are taken. No limits are given for $\Lambda^{\pm}_{LL}$ with $(\eta_{LL},\eta_{LR}) = (\pm1,0)$. For more general constraints with right-handed neutrinos and chirality nonconserving contact interactions, see their text. NODE=S054CTN;LINKAGE=B

[26] DIAZCRUZ 94 limits are from $\Gamma(\tau \rightarrow e\nu\nu)$ and assume flavor-dependent contact interactions with $\Lambda(\tau\nu_\tau e \nu_e) \ll \Lambda(\mu\nu_\mu e \nu_e)$. NODE=S054CTN;LINKAGE=A

[27] DIAZCRUZ 94 limits are from $\Gamma(\tau \rightarrow \mu\nu\nu)$ and assume flavor-dependent contact interactions with $\Lambda(\tau\nu_\tau \mu \nu_\mu) \ll \Lambda(\mu\nu_\mu e \nu_e)$. NODE=S054CTN;LINKAGE=C

SCALE LIMITS for Contact Interactions: $\Lambda(e\nu q q)$

NODE=S054CQN
NODE=S054CQN

VALUE (TeV)	CL%	DOCUMENT ID		TECN
>2.81	95	[28] AFFOLDER	01I	CDF

[28] AFFOLDER 00I bound is for a scalar interaction $\overline{q}_R q_L \overline{\nu} e_L$. NODE=S054CQN;LINKAGE=LI

SCALE LIMITS for Contact Interactions: $\Lambda(qqqq)$

NODE=S054CTQ

Limits are for $\Lambda^{\pm}_{LL}$ with color-singlet isoscalar exchanges among u_L's and d_L's only, unless otherwise noted. See EICHTEN 84 for details. NODE=S054CTQ

NODE=S054CTQ

VALUE (TeV)	CL%	DOCUMENT ID		TECN	COMMENT
>7.6 (CL = 95%)	[>5.6 TeV (CL = 95%) OUR 2012 BEST LIMIT]				
>7.6	95	[29] AAD	13D	ATLS	$pp \rightarrow$ dijet angl.
>7.5	95	[30] CHATRCHYAN	12Z	CMS	$pp \rightarrow$ dijet angl.; Λ^{+}_{LL}
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>3.4	95	[31] AAD	11	ATLS	$pp \rightarrow$ dijet; Λ^{+}_{LL}
>5.6	95	[32] KHACHATRY...	11F	CMS	$pp \rightarrow$ dijet angl.; Λ^{+}_{LL}
>4.0	95	[33] KHACHATRY...	10A	CMS	pp; dijet centrality; Λ^{+}_{LL}
>2.96	95	[34] ABAZOV	09AE	D0	$p\overline{p} \rightarrow$ dijet, angl. Λ^{+}_{LL}

[29] AAD 13D limit is from dijet angular distribution in pp collisions at E_{cm} = 7 TeV. The constant prior in $1/\Lambda^4$ is applied. NODE=S054CTQ;LINKAGE=L

[30] CHATRCHYAN 12Z limit is from dijet angular distribution in pp collisions at E_{cm} = 7 TeV. They also obtain Λ^-_{LL} > 10.5 TeV. NODE=S054CTQ;LINKAGE=M

[31] AAD 11 limit is from dijet angular distribution and dijet centrality ratio in pp collisions at E_{cm} = 7 TeV. NODE=S054CTQ;LINKAGE=AA

[32] KHACHATRYAN 11F limit is from dijet angular distribution in pp collisions at E_{cm} = 7 TeV. They also obtain Λ^-_{LL} > 6.7 TeV. NODE=S054CTQ;LINKAGE=KA

[33] The quoted limit is from dijet centrality ratio measurement in pp collisions at $\sqrt{s}$=7 TeV. NODE=S054CTQ;LINKAGE=KH

[34] ABAZOV 09AE also obtain Λ^-_{LL} >2.96 TeV. NODE=S054CTQ;LINKAGE=AB

SCALE LIMITS for Contact Interactions: $\Lambda(\nu\nu qq)$

NODE=S054CTD

Limits are for $\Lambda^{\pm}_{LL}$ only. For other cases, see each reference.

NODE=S054CTD
NODE=S054CTD

Λ^+_{LL}(TeV)	Λ^-_{LL}(TeV)	CL%	DOCUMENT ID	TECN	COMMENT
>5.0	**>5.4**	95	[35] MCFARLAND 98	CCFR	νN scattering

[35] MCFARLAND 98 assumed a flavor universal interaction. Neutrinos were mostly of muon type. NODE=S054CTD;LINKAGE=A

MASS LIMITS for Excited e (e^*)

NODE=S054220

Most e^+e^- experiments assume one-photon or Z exchange. The limits from some e^+e^- experiments which depend on λ have assumed transition couplings which are chirality violating ($\eta_L = \eta_R$). However they can be interpreted as limits for chirality-conserving interactions after multiplying the coupling value λ by $\sqrt{2}$; see Note.

NODE=S054220

Excited leptons have the same quantum numbers as other ortholeptons. See also the searches for ortholeptons in the "Searches for Heavy Leptons" section.

Limits for Excited e (e^*) from Pair Production

NODE=S054EXP

These limits are obtained from $e^+e^- \rightarrow e^{*+}e^{*-}$ and thus rely only on the (electroweak) charge of e^*. Form factor effects are ignored unless noted. For the case of limits from Z decay, the e^* coupling is assumed to be of sequential type. Possible t channel contribution from transition magnetic coupling is neglected. All limits assume a dominant $e^* \rightarrow e\gamma$ decay except the limits from $\Gamma(Z)$.

NODE=S054EXP

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)).

NODE=S054EXP

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
>103.2	95	[36] ABBIENDI 02G	OPAL	$e^+e^- \rightarrow e^*e^*$ Homodoublet type
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>102.8	95	[37] ACHARD 03B	L3	$e^+e^- \rightarrow e^*e^*$ Homodoublet type

[36] From e^+e^- collisions at $\sqrt{s}$ = 183–209 GeV. $f = f'$ is assumed. NODE=S054EXP;LINKAGE=GN

[37] From e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = f'$ is assumed. ACHARD 03B also obtain limit for $f = -f'$: $m_{e^*} > 96.6$ GeV. NODE=S054EXP;LINKAGE=CR

Limits for Excited e (e^*) from Single Production

NODE=S054EXS

These limits are from $e^+e^- \rightarrow e^*e$, $W \rightarrow e^*\nu$, or $ep \rightarrow e^*X$ and depend on transition magnetic coupling between e and e^*. All limits assume $e^* \rightarrow e\gamma$ decay except as noted. Limits from LEP, UA2, and H1 are for chiral coupling, whereas all other limits are for nonchiral coupling, $\eta_L = \eta_R = 1$. In most papers, the limit is expressed in the form of an excluded region in the $\lambda - m_{e^*}$ plane. See the original papers.

NODE=S054EXS

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)).

NODE=S054EXS

VALUE (GeV)	CL%	DOCUMENT ID	TECN	COMMENT
> 1.870 × 10^3 (CL = 95%) [>1.070 × 10^3 GeV (CL = 95%) OUR 2012 BEST LIMIT]				
>1870	95	[38] AAD 12AZ	ATLS	$pp \rightarrow e^{(*)}e^*X$

• • • We do not use the following data for averages, fits, limits, etc. • • •

>1070	95	[39] CHATRCHYAN	11X	CMS	$p p \to e e^* X$
> 272	95	[40] AARON	08A	H1	$e p \to e^* X$
		[41] ABAZOV	08H	D0	$p \overline{p} \to e^* e$
> 209	95	[42] ACOSTA	05B	CDF	$p \overline{p} \to e^* X$
> 206	95	[43] ACHARD	03B	L3	$e^+ e^- \to e e^*$
> 208	95	[44] ABBIENDI	02G	OPAL	$e^+ e^- \to e e^*$
> 228	95	[45] CHEKANOV	02D	ZEUS	$e p \to e^* X$

[38] AAD 12AZ search for e^* production via four-fermion contact interaction in $p p$ collisions with $e^* \to e\gamma$ decay. The quoted limit assumes $\Lambda = m_{e^*}$. See their Fig. 8 for the exclusion plot in the mass-coupling plane. NODE=S054EXS;LINKAGE=B

[39] CHATRCHYAN 11X search for single e^* production in $p p$ collisions with the decay $e^* \to e\gamma$. $f = f' = \Lambda/m_{e^*}$ is assumed. See their Fig. 2 for the exclusion plot in the mass-coupling plane. NODE=S054EXS;LINKAGE=CH

[40] AARON 08A search for single e^* production in $e p$ collisions with the decays $e^* \to e\gamma$, $e Z$, νW. The quoted limit assumes $f = f' = \Lambda/m_{e^*}$. See their Fig. 3 and Fig. 4 for the exclusion plots in the mass-coupling plane. NODE=S054EXS;LINKAGE=AA

[41] ABAZOV 08H search for single e^* production in $p \overline{p}$ collisions with the decays $e^* \to e\gamma$. The e^* production is assumed to be described by an effective four-fermion interaction. See their Fig. 5 for the exclusion plot in the mass-coupling plane. NODE=S054EXS;LINKAGE=AB

[42] ACOSTA 05B search for single e^* production in $p \overline{p}$ collisions with the decays $e^* \to e\gamma$. $f = f' = \Lambda/m_{e^*}$ is assumed for the e^* coupling. See their Fig.3 for the exclusion limit in the mass-coupling plane. NODE=S054EXS;LINKAGE=AC

[43] ACHARD 03B result is from $e^+ e^-$ collisions at $\sqrt{s} = 189$–209 GeV. See their Fig. 4 for the exclusion plot in the mass-coupling plane. NODE=S054EXS;LINKAGE=CR

[44] ABBIENDI 02G result is from $e^+ e^-$ collisions at $\sqrt{s} = 183$–209 GeV. $f = f' = \Lambda/m_{e^*}$ is assumed for e^* coupling. See their Fig. 4c for the exclusion limit in the mass-coupling plane. NODE=S054EXS;LINKAGE=GN

[45] CHEKANOV 02D search for single e^* production in $e p$ collisions with the decays $e^* \to e\gamma$, $e Z$, νW. $f = f' = \Lambda/m_{e^*}$ is assumed for the e^* coupling. See their Fig. 5a for the exclusion plot in the mass-coupling plane. NODE=S054EXS;LINKAGE=KD

Limits for Excited e (e^*) from $e^+ e^- \to \gamma\gamma$

NODE=S054EXG

NODE=S054EXG

These limits are derived from indirect effects due to e^* exchange in the t channel and depend on transition magnetic coupling between e and e^*. All limits are for $\lambda_\gamma = 1$. All limits except ABE 89J and ACHARD 02D are for nonchiral coupling with $\eta_L = \eta_R = 1$. We choose the chiral coupling limit as the best limit and list it in the Summary Table.

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)). NODE=S054EXG

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>356	95	[46] ABDALLAH	04N	DLPH	$\sqrt{s}$= 161–208 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>310	95	ACHARD	02D	L3	$\sqrt{s}$= 192–209 GeV

[46] ABDALLAH 04N also obtain a limit on the excited electron mass with $e e^*$ chiral coupling, $m_{e^*} > 295$ GeV at 95% CL. NODE=S054EXG;LINKAGE=AB

Indirect Limits for Excited e (e^*)

NODE=S054EXI

NODE=S054EXI

These limits make use of loop effects involving e^* and are therefore subject to theoretical uncertainty.

NODE=S054EXI

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[47] DORENBOS...	89	CHRM	$\overline{\nu}_\mu e \to \overline{\nu}_\mu e$, $\nu_\mu e \to \nu_\mu e$
	[48] GRIFOLS	86	THEO	$\nu_\mu e \to \nu_\mu e$
	[49] RENARD	82	THEO	$g-2$ of electron

[47] DORENBOSCH 89 obtain the limit $\lambda_\gamma^2 \Lambda_{\text{cut}}^2/m_{e^*}^2 < 2.6$ (95% CL), where Λ_{cut} is the cutoff scale, based on the one-loop calculation by GRIFOLS 86. If one assumes that $\Lambda_{\text{cut}} = 1$ TeV and $\lambda_\gamma = 1$, one obtains $m_{e^*} > 620$ GeV. However, one generally expects $\lambda_\gamma \approx m_{e^*}/\Lambda_{\text{cut}}$ in composite models. NODE=S054EXI;LINKAGE=DD

[48] GRIFOLS 86 uses $\nu_\mu e \to \nu_\mu e$ and $\overline{\nu}_\mu e \to \overline{\nu}_\mu e$ data from CHARM Collaboration to derive mass limits which depend on the scale of compositeness. NODE=S054EXI;LINKAGE=H

[49] RENARD 82 derived from $g-2$ data limits on mass and couplings of e^* and μ^*. See figures 2 and 3 of the paper. NODE=S054EXI;LINKAGE=E

MASS LIMITS for Excited μ (μ^*)

NODE=S054225

Limits for Excited μ (μ^*) from Pair Production

NODE=S054MXP
NODE=S054MXP

These limits are obtained from $e^+e^- \to \mu^{*+}\mu^{*-}$ and thus rely only on the (electroweak) charge of μ^*. Form factor effects are ignored unless noted. For the case of limits from Z decay, the μ^* coupling is assumed to be of sequential type. All limits assume a dominant $\mu^* \to \mu\gamma$ decay except the limits from $\Gamma(Z)$.

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)).

NODE=S054MXP

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>103.2	95	[50] ABBIENDI	02G	OPAL	$e^+e^- \to \mu^*\mu^*$ Homodoublet type
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>102.8	95	[51] ACHARD	03B	L3	$e^+e^- \to \mu^*\mu^*$ Homodoublet type

[50] From e^+e^- collisions at $\sqrt{s}$ = 183–209 GeV. $f = f'$ is assumed.

NODE=S054MXP;LINKAGE=GN

[51] From e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = f'$ is assumed. ACHARD 03B also obtain limit for $f = -f'$: $m_{\mu^*} > 96.6$ GeV.

NODE=S054MXP;LINKAGE=CR

Limits for Excited μ (μ^*) from Single Production

NODE=S054MXS
NODE=S054MXS

These limits are from $e^+e^- \to \mu^*\mu$ and depend on transition magnetic coupling between μ and μ^*. All limits assume $\mu^* \to \mu\gamma$ decay. Limits from LEP are for chiral coupling, whereas all other limits are for nonchiral coupling, $\eta_L = \eta_R = 1$. In most papers, the limit is expressed in the form of an excluded region in the $\lambda - m_{\mu^*}$ plane. See the original papers.

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)).

NODE=S054MXS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
> 1.750 × 10^3 (CL = 95%) [>1.090 × 10^3 GeV (CL = 95%) OUR 2012 BEST LIMIT]					
>1750	95	[52] AAD	12AZ	ATLS	$pp \to \mu^{(*)}\mu^* X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>1090	95	[53] CHATRCHYAN	11X	CMS	$pp \to \mu\mu^* X$
	95	[54] ABAZOV	06E	D0	$p\overline{p} \to \mu\mu^*$
> 221	95	[55] ABULENCIA,A	06B	CDF	$p\overline{p} \to \mu\mu^*$, $\mu^* \to \mu\gamma$
> 180	95	[56] ACHARD	03B	L3	$e^+e^- \to \mu\mu^*$
> 190	95	[57] ABBIENDI	02G	OPAL	$e^+e^- \to \mu\mu^*$

[52] AAD 12AZ search for μ^* production via four-fermion contact interaction in pp collisions with $\mu^* \to \mu\gamma$ decay. The quoted limit assumes $\Lambda = m_{\mu^*}$. See their Fig. 8 for the exclusion plot in the mass-coupling plane.

NODE=S054MXS;LINKAGE=A

[53] CHATRCHYAN 11X search for single μ^* production in pp collisions with the decay $\mu^* \to \mu\gamma$. $f = f' = \Lambda/m_{\mu^*}$ is assumed. See their Fig. 2 for the exclusion plot in the mass-coupling plane.

NODE=S054MXS;LINKAGE=CH

[54] ABAZOV 06E assume $\mu\mu^*$ production via four-fermion contact interaction $(4\pi/\Lambda^2)(\overline{q}_L\gamma^\mu q_L)(\overline{\mu}^*_L\gamma_\mu\mu)$. The obtained limit is $m_{\mu^*} > 618$ GeV ($m_{\mu^*} > 688$ GeV) for $\Lambda = 1$ TeV ($\Lambda = m_{\mu^*}$).

NODE=S054MXS;LINKAGE=VO

[55] $f = f' = \Lambda/m_{\mu^*}$ is assumed for the μ^* coupling. See their Fig.4 for the exclusion limit in the mass-coupling plane. ABULENCIA,A 06B also obtain m_{μ^*} limit in the contact interaction model with $\Lambda = m_{\mu^*}$, $m_{\mu^*} > 696$ GeV.

NODE=S054MXS;LINKAGE=UL

[56] ACHARD 03B result is from e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = f' = \Lambda/m_{\mu^*}$ is assumed. See their Fig. 4 for the exclusion plot in the mass-coupling plane.

NODE=S054MXS;LINKAGE=CR

[57] ABBIENDI 02G result is from e^+e^- collisions at $\sqrt{s}$ = 183–209 GeV. $f = f' = \Lambda/m_{\mu^*}$ is assumed for μ^* coupling. See their Fig. 4c for the exclusion limit in the mass-coupling plane.

NODE=S054MXS;LINKAGE=GN

Indirect Limits for Excited μ (μ^*)

NODE=S054MXI
NODE=S054MXI

These limits make use of loop effects involving μ^* and are therefore subject to theoretical uncertainty.

NODE=S054MXI

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[58] RENARD	82	THEO	$g-2$ of muon

[58] RENARD 82 derived from $g-2$ data limits on mass and couplings of e^* and μ^*. See figures 2 and 3 of the paper.

NODE=S054MXI;LINKAGE=O

MASS LIMITS for Excited τ (τ^*)

NODE=S054230

Limits for Excited τ (τ^*) from Pair Production

NODE=S054TXP

NODE=S054TXP

These limits are obtained from $e^+e^- \rightarrow \tau^{*+}\tau^{*-}$ and thus rely only on the (electroweak) charge of τ^*. Form factor effects are ignored unless noted. For the case of limits from Z decay, the τ^* coupling is assumed to be of sequential type. All limits assume a dominant $\tau^* \rightarrow \tau\gamma$ decay except the limits from $\Gamma(Z)$.

For limits prior to 1987, see our 1992 edition (Physical Review **D45** S1 (1992)).

NODE=S054TXP

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>103.2	95	[59] ABBIENDI	02G	OPAL	$e^+e^- \rightarrow \tau^*\tau^*$ Homodoublet type
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>102.8	95	[60] ACHARD	03B	L3	$e^+e^- \rightarrow \tau^*\tau^*$ Homodoublet type

[59] From e^+e^- collisions at $\sqrt{s}$ = 183–209 GeV. $f = f'$ is assumed. NODE=S054TXP;LINKAGE=GN

[60] From e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = f'$ is assumed. ACHARD 03B also obtain limit for $f = -f'$: $m_{\tau^*} > 96.6$ GeV. NODE=S054TXP;LINKAGE=CR

Limits for Excited τ (τ^*) from Single Production

NODE=S054TXS

NODE=S054TXS

These limits are from $e^+e^- \rightarrow \tau^*\tau$ and depend on transition magnetic coupling between τ and τ^*. All limits assume $\tau^* \rightarrow \tau\gamma$ decay. Limits from LEP are for chiral coupling, whereas all other limits are for nonchiral coupling, $\eta_L = \eta_R = 1$. In most papers, the limit is expressed in the form of an excluded region in the $\lambda - m_{\tau^*}$ plane. See the original papers.

NODE=S054TXS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>185	95	[61] ABBIENDI	02G	OPAL	$e^+e^- \rightarrow \tau\tau^*$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>180	95	[62] ACHARD	03B	L3	$e^+e^- \rightarrow \tau\tau^*$

[61] ABBIENDI 02G result is from e^+e^- collisions at $\sqrt{s}$ = 183–209 GeV. $f = f' = \Lambda/m_{\tau^*}$ is assumed for τ^* coupling. See their Fig. 4c for the exclusion limit in the mass-coupling plane. NODE=S054TXS;LINKAGE=GN

[62] ACHARD 03B result is from e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = f' = \Lambda/m_{\tau^*}$ is assumed. See their Fig. 4 for the exclusion plot in the mass-coupling plane. NODE=S054TXS;LINKAGE=CR

MASS LIMITS for Excited Neutrino (ν^*)

NODE=S054233

Limits for Excited ν (ν^*) from Pair Production

NODE=S054EXN

NODE=S054EXN

These limits are obtained from $e^+e^- \rightarrow \nu^*\nu^*$ and thus rely only on the (electroweak) charge of ν^*. Form factor effects are ignored unless noted. The ν^* coupling is assumed to be of sequential type unless otherwise noted. All limits assume a dominant $\nu^* \rightarrow \nu\gamma$ decay except the limits from $\Gamma(Z)$.

NODE=S054EXN

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>102.6	95	[63] ACHARD	03B	L3	$e^+e^- \rightarrow \nu^*\nu^*$ Homodoublet type
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[64] ABBIENDI	04N	OPAL	

[63] From e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. $f = -f'$ is assumed. ACHARD 03B also obtain limit for $f = f'$: $m_{\nu_e^*} > 101.7$ GeV, $m_{\nu_\mu^*} > 101.8$ GeV, and $m_{\nu_\tau^*} > 92.9$ GeV. See their Fig. 4 for the exclusion plot in the mass-coupling plane. NODE=S054EXN;LINKAGE=CR

[64] From e^+e^- collisions at $\sqrt{s}$ = 192–209 GeV, ABBIENDI 04N obtain limit on $\sigma(e^+e^- \rightarrow \nu^*\nu^*)\ B^2(\nu^* \rightarrow \nu\gamma)$. See their Fig.2. The limit ranges from 20 to 45fb for $m_{\nu^*} > 45$ GeV. NODE=S054EXN;LINKAGE=AB

Limits for Excited ν (ν^*) from Single Production

NODE=S054EXO

NODE=S054EXO

These limits are from $e^+e^- \rightarrow \nu\nu^*$, $Z \rightarrow \nu\nu^*$, or $ep \rightarrow \nu^* X$ and depend on transition magnetic coupling between ν/e and ν^*. Assumptions about ν^* decay mode are given in footnotes.

NODE=S054EXO

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>213	95	[65] AARON	08	H1	$ep \rightarrow \nu^* X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>190	95	[66] ACHARD	03B	L3	$e^+e^- \rightarrow \nu\nu^*$
none 50–150	95	[67] ADLOFF	02	H1	$ep \rightarrow \nu^* X$
>158	95	[68] CHEKANOV	02D	ZEUS	$ep \rightarrow \nu^* X$
>171	95	[69] ACCIARRI	01D	L3	$e^+e^- \rightarrow \nu\nu^*$

[65] AARON 08 search for single ν^* production in ep collisions with the decays $\nu^* \to \nu\gamma$, νZ, eW. The quoted limit assumes $f = -f' = \Lambda/m_{\nu^*}$. See their Fig. 3 and Fig. 4 for the exclusion plots in the mass-coupling plane. NODE=S054EXO;LINKAGE=AA

[66] ACHARD 03B result is from e^+e^- collisions at $\sqrt{s}$ = 189–209 GeV. The quoted limit is for ν^*_e. $f = -f' = \Lambda/m_{\nu^*}$ is assumed. See their Fig. 4 for the exclusion plot in the mass-coupling plane. NODE=S054EXO;LINKAGE=CR

[67] ADLOFF 02 search for single ν^* production in ep collisions with the decays $\nu^* \to \nu\gamma$, νZ, eW. The quoted limit assumes $f = -f' = \Lambda/m_{\nu^*}$. See their Fig. 1 for the exclusion plots in the mass-coupling plane. NODE=S054EXO;LINKAGE=LF

[68] CHEKANOV 02D search for single ν^* production in ep collisions with the decays $\nu^* \to \nu\gamma$, νZ, eW. $f = -f' = \Lambda/m_{\nu^*}$ is assumed for the e^* coupling. CHEKANOV 02D also obtain limit for $f = f' = \Lambda/m_{\nu^*}$: m_{ν^*} >135 GeV. See their Fig. 5c and Fig. 5d for the exclusion plot in the mass-coupling plane. NODE=S054EXO;LINKAGE=KD

[69] ACCIARRI 01D search for $\nu\nu^*$ production in e^+e^- collisions at $\sqrt{s}$ = 192–202 GeV with decays $\nu^* \to \nu\gamma$, $\nu^* \to eW$. $f=-f'=\Lambda/m_{\nu^*}$ is assumed for the ν^* coupling. See their Fig. 4 for limits in the mass-coupling plane. NODE=S054EXO;LINKAGE=XK

MASS LIMITS for Excited q (q^*)

NODE=S054235

Limits for Excited q (q^*) from Pair Production

NODE=S054EQP

These limits are mostly obtained from $e^+e^- \to q^*\overline{q}^*$ and thus rely only on the (electroweak) charge of the q^*. Form factor effects are ignored unless noted. Assumptions about the q^* decay are given in the comments and footnotes.

NODE=S054EQP

NODE=S054EQP

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
>338	95	[70] AALTONEN	10H	CDF	$q^* \to tW^-$	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
		[71] BARATE	98U	ALEP	$Z \to q^*q^*$	
> 45.6	95	[72] ADRIANI	93M	L3	u or d type, $Z \to q^*q^*$	
> 41.7	95	[73] BARDADIN-...	92	RVUE	u-type, $\Gamma(Z)$	
> 44.7	95	[73] BARDADIN-...	92	RVUE	d-type, $\Gamma(Z)$	OCCUR=2
> 40.6	95	[74] DECAMP	92	ALEP	u-type, $\Gamma(Z)$	OCCUR=3
> 44.2	95	[74] DECAMP	92	ALEP	d-type, $\Gamma(Z)$	OCCUR=4
> 45	95	[75] DECAMP	92	ALEP	u or d type, $Z \to q^*q^*$	OCCUR=5
> 45	95	[74] ABREU	91F	DLPH	u-type, $\Gamma(Z)$	
> 45	95	[74] ABREU	91F	DLPH	d-type, $\Gamma(Z)$	OCCUR=2

[70] AALTONEN 10H obtain limits on the q^*q^* production cross section in $p\overline{p}$ collisions. See their Fig. 3. NODE=S054EQP;LINKAGE=AA

[71] BARATE 98U obtain limits on the form factor. See their Fig. 16 for limits in mass-form factor plane. NODE=S054EQP;LINKAGE=BU

[72] ADRIANI 93M limit is valid for B($q^* \to qg$)> 0.25 (0.17) for up (down) type. NODE=S054EQP;LINKAGE=E

[73] BARDADIN-OTWINOWSKA 92 limit based on $\Delta\Gamma(Z)$<36 MeV. NODE=S054EQP;LINKAGE=BO

[74] These limits are independent of decay modes. NODE=S054EQP;LINKAGE=I

[75] Limit is for B($q^* \to qg$)+B($q^* \to q\gamma$)=1. NODE=S054EQP;LINKAGE=J

Limits for Excited q (q^*) from Single Production

NODE=S054EQS

These limits are from $e^+e^- \to q^*\overline{q}$, $p\overline{p} \to q^*X$, or $pp \to q^*X$ and depend on transition magnetic couplings between q and q^*. Assumptions about q^* decay mode are given in the footnotes and comments.

NODE=S054EQS

NODE=S054EQS

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
> 3.320 × 10^3 (CL = 95%) [>2.490 × 10^3 GeV (CL = 95%) OUR 2012 BEST LIMIT]					
>3320	95	[76] CHATRCHYAN	13A	CMS	$pp \to q^*X$, $q^* \to qg$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>2460	95	[77] AAD	12AO	ATLS	$pp \to q^*X$, $q^* \to q\gamma$
>2990	95	[78] AAD	12S	ATLS	$pp \to q^*X$, $q^* \to qg$
		[79] ABAZOV	11F	D0	$p\overline{p} \to q^*X$, $q^* \to qZ,qW$
>2490	95	[80] CHATRCHYAN	11Y	CMS	$pp \to q^*X$, $q^* \to qg$
none 300–1260	95	[81] AAD	10	ATLS	$pp \to q^*X$, $q^* \to qg$
none 500–1580	95	[81] KHACHATRY...	10	CMS	$pp \to q^*X$, $q^* \to qg$
> 510	95	[82] ABAZOV	06F	D0	$p\overline{p} \to q^*X$, $q^* \to qZ$
> 775	95	[83] ABAZOV	04C	D0	$p\overline{p} \to q^*X$, $q^* \to qg$

[76] CHATRCHYAN 13A assume $\Lambda = m_{q^*}$.
[77] AAD 12AO assume $\Lambda = m_{q^*}$, $f_s = f = f' = 1$.
[78] AAD 12S assume $\Lambda = m_{q^*}$.
[79] ABAZOV 11F search for vectorlike quarks decaying to W+jet and Z+jet in $p\overline{p}$ collisions. See their Fig. 3 and Fig. 4 for the limits on $\sigma \cdot$ B.
[80] CHATRCHYAN 11Y assume degenerate q^* with $f_s = \Lambda/m_{q^*}$.
[81] AAD 10, KHACHATRYAN 10 search for heavy resonance decaying to 2 jets in pp collisions at $\sqrt{s} = 7$ TeV. $f_s = f = f' = 1$ is assumed.
[82] ABAZOV 06F assume q^* production via qg fusion and via contact interactions. The quoted limit is for $\Lambda = m_{q^*}$.
[83] ABAZOV 04C assume $f_s = f = f' = \Lambda/m_{q^*}$.

NODE=S054EQS;LINKAGE=F
NODE=S054EQS;LINKAGE=G
NODE=S054EQS;LINKAGE=A
NODE=S054EQS;LINKAGE=AZ
NODE=S054EQS;LINKAGE=CH
NODE=S054EQS;LINKAGE=AA
NODE=S054EQS;LINKAGE=VO
NODE=S054EQS;LINKAGE=AB

MASS LIMITS for Color Sextet Quarks (q_6)

NODE=S054CQ
NODE=S054CQ

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>84	95	[84] ABE	89D	CDF	$p\overline{p} \rightarrow q_6 \overline{q}_6$

[84] ABE 89D look for pair production of unit-charged particles which leave the detector before decaying. In the above limit the color sextet quark is assumed to fragment into a unit-charged or neutral hadron with equal probability and to have long enough lifetime not to decay within the detector. A limit of 121 GeV is obtained for a color decuplet.

NODE=S054CQ;LINKAGE=A

MASS LIMITS for Color Octet Charged Leptons (ℓ_8)

NODE=S054CL

$\lambda \equiv m_{\ell_8}/\Lambda$

NODE=S054CL
NODE=S054CL

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>86	95	[85] ABE	89D	CDF	Stable ℓ_8: $p\overline{p} \rightarrow \ell_8 \overline{\ell}_8$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[86] ABT	93	H1	e_8: $ep \rightarrow e_8 X$

[85] ABE 89D look for pair production of unit-charged particles which leave the detector before decaying. In the above limit the color octet lepton is assumed to fragment into a unit-charged or neutral hadron with equal probability and to have long enough lifetime not to decay within the detector. The limit improves to 99 GeV if it always fragments into a unit-charged hadron.
[86] ABT 93 search for e_8 production via e-gluon fusion in ep collisions with $e_8 \rightarrow eg$. See their Fig. 3 for exclusion plot in the m_{e_8}–Λ plane for $m_{e_8} = 35$–220 GeV.

NODE=S054CL;LINKAGE=AC
NODE=S054CL;LINKAGE=G2

MASS LIMITS for Color Octet Neutrinos (ν_8)

NODE=S054CN

$\lambda \equiv m_{\ell_8}/\Lambda$

NODE=S054CN
NODE=S054CN

VALUE (GeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
>110	90	[87] BARGER	89	RVUE	ν_8: $p\overline{p} \rightarrow \nu_8 \overline{\nu}_8$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
none 3.8–29.8	95	[88] KIM	90	AMY	ν_8: $e^+ e^- \rightarrow$ acoplanar jets
none 9–21.9	95	[89] BARTEL	87B	JADE	ν_8: $e^+ e^- \rightarrow$ acoplanar jets

OCCUR=3

[87] BARGER 89 used ABE 89B limit for events with large missing transverse momentum. Two-body decay $\nu_8 \rightarrow \nu g$ is assumed.
[88] KIM 90 is at $E_{cm} = 50$–60.8 GeV. The same assumptions as in BARTEL 87B are used.
[89] BARTEL 87B is at $E_{cm} = 46.3$–46.78 GeV. The limit assumes the ν_8 pair production cross section to be eight times larger than that of the corresponding heavy neutrino pair production. This assumption is not valid in general for the weak couplings, and the limit can be sensitive to its $SU(2)_L \times U(1)_Y$ quantum numbers.

NODE=S054CN;LINKAGE=C
NODE=S054CN;LINKAGE=D
NODE=S054CN;LINKAGE=A

MASS LIMITS for W_8 (Color Octet W Boson)

NODE=S054CW
NODE=S054CW

VALUE (GeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[90] ALBAJAR	89	UA1	$p\overline{p} \rightarrow W_8 X$, $W_8 \rightarrow Wg$

[90] ALBAJAR 89 give $\sigma(W_8 \rightarrow W + \text{jet})/\sigma(W) < 0.019$ (90% CL) for $m_{W_8} > 220$ GeV.

NODE=S054CW;LINKAGE=A

REFERENCES FOR Searches for Quark and Lepton Compositeness

NODE=S054

AAD	13D	JHEP 1301 029	G. Aad *et al.*	(ATLAS Collab.)	REFID=54792
AAD	13E	PR D87 015010	G. Aad *et al.*	(ATLAS Collab.)	REFID=54828
CHATRCHYAN	13A	JHEP 1301 013	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54770
CHATRCHYAN	13K	PR D87 032001	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54943
AAD	12AB	PL B712 40	G. Aad *et al.*	(ATLAS Collab.)	REFID=54172
AAD	12AO	PRL 108 211802	G. Aad *et al.*	(ATLAS Collab.)	REFID=54224
AAD	12AZ	PR D85 072003	G. Aad *et al.*	(ATLAS Collab.)	REFID=54355
AAD	12S	PL B708 37	G. Aad *et al.*	(ATLAS Collab.)	REFID=54152
CHATRCHYAN	12Z	JHEP 1205 055	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54462
AAD	11	PL B694 327	G. Aad *et al.*	(ATLAS Collab.)	REFID=53604
AAD	11E	PR D84 011101	G. Aad *et al.*	(ATLAS Collab.)	REFID=16557
AARON	11C	PL B705 52	F. D. Aaron *et al.*	(H1 Collab.)	REFID=53845
ABAZOV	11F	PRL 106 081801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=16469
ABDALLAH	11	EPJ C71 1555	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=16401
CHATRCHYAN	11X	PL B704 143	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=53868
CHATRCHYAN	11Y	PL B704 123	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=53869
KHACHATRY...	11F	PRL 106 201804	V. Khachatryan *et al.*	(CMS Collab.)	REFID=16625
AAD	10	PRL 105 161801	G. Aad *et al.*	(ATLAS Collab.)	REFID=53477
AALTONEN	10H	PRL 104 091801	T. Aaltonen *et al.*	(CDF Collab.)	REFID=53271
KHACHATRY...	10	PRL 105 211801	V. Khachatryan *et al.*	(CMS Collab.)	REFID=53465
Also		PRL 106 029902	V. Khachatryan *et al.*	(CMS Collab.)	REFID=53629
KHACHATRY...	10A	PRL 105 262001	V. Khachatryan *et al.*	(CMS Collab.)	REFID=53582
ABAZOV	09AE	PRL 103 191803	V.M. Abazov *et al.*	(D0 Collab.)	REFID=53064
ABDALLAH	09	EPJ C60 1	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=52838
AARON	08	PL B663 382	F.D. Aaron *et al.*	(H1 Collab.)	REFID=52458
AARON	08A	PL B666 131	F.D. Aaron *et al.*	(H1 Collab.)	REFID=52464
ABAZOV	08H	PR D77 091102	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52345
SCHAEL	07A	EPJ C49 411	S. Schael *et al.*	(ALEPH Collab.)	REFID=51743
ABAZOV	06E	PR D73 111102	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51276
ABAZOV	06F	PR D74 011104	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51293
ABDALLAH	06C	EPJ C45 589	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=51224
ABULENCIA	06L	PRL 96 211801	A. Abulencia *et al.*	(CDF Collab.)	REFID=51233
ABULENCIA,A	06B	PRL 97 191802	A. Abulencia *et al.*	(CDF Collab.)	REFID=51484
ACOSTA	05B	PRL 94 101802	D. Acosta *et al.*	(CDF Collab.)	REFID=50582
ABAZOV	04C	PR D69 111101	V.M. Abazov *et al.*	(D0 Collab.)	REFID=50005
ABBIENDI	04G	EPJ C33 173	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49915
ABBIENDI	04N	PL B602 167	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=50288
ABDALLAH	04N	EPJ C37 405	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=50302
ACHARD	03B	PL B568 23	P. Achard *et al.*	(L3 Collab.)	REFID=49521
BABICH	03	EPJ C29 103	A.A. Babich *et al.*		REFID=49461
ABBIENDI	02G	PL B544 57	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48917
ACHARD	02D	PL B531 28	P. Achard *et al.*	(L3 Collab.)	REFID=48663
ADLOFF	02	PL B525 9	C. Adloff *et al.*	(H1 Collab.)	REFID=48526
CHEKANOV	02D	PL B549 32	S. Chekanov *et al.*	(ZEUS Collab.)	REFID=49089
ACCIARRI	01D	PL B502 37	M. Acciarri *et al.*	(L3 Collab.)	REFID=48096
AFFOLDER	01I	PRL 87 231803	T. Affolder *et al.*	(CDF Collab.)	REFID=48438
BOURILKOV	01	PR D64 071701	D. Bourilkov		REFID=48368
CHEUNG	01B	PL B517 167	K. Cheung		REFID=48289
ABREU	00S	PL B485 45	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47716
ACCIARRI	00P	PL B489 81	M. Acciarri *et al.*	(L3 Collab.)	REFID=47757
AFFOLDER	00I	PR D62 012004	T. Affolder *et al.*	(CDF Collab.)	REFID=47663
BARATE	98U	EPJ C4 571	R. Barate *et al.*	(ALEPH Collab.)	REFID=46150
BARGER	98E	PR D57 391	V. Barger *et al.*		REFID=48063
MCFARLAND	98	EPJ C1 509	K.S. McFarland *et al.*	(CCFR/NuTeV Collab.)	REFID=46144
ABE	97T	PRL 79 2198	F. Abe *et al.*	(CDF Collab.)	REFID=45596
DIAZCRUZ	94	PR D49 R2149	J.L. Diaz Cruz, O.A. Sampayo	(CINV)	REFID=43731
ABT	93	NP B396 3	I. Abt *et al.*	(H1 Collab.)	REFID=43371
ADRIANI	93M	PRPL 236 1	O. Adriani *et al.*	(L3 Collab.)	REFID=43644
BARDADIN-...	92	ZPHY C55 163	M. Bardadin-Otwinowska	(CLER)	REFID=42109
DECAMP	92	PRPL 216 253	D. Decamp *et al.*	(ALEPH Collab.)	REFID=41877
PDG	92	PR D45 S1	K. Hikasa *et al.*	(KEK, LBL, BOST+)	REFID=41900
ABREU	91F	NP B367 511	P. Abreu *et al.*	(DELPHI Collab.)	REFID=41840
KIM	90	PL B240 243	G.N. Kim *et al.*	(AMY Collab.)	REFID=41211
ABE	89B	PRL 62 1825	F. Abe *et al.*	(CDF Collab.)	REFID=40784
ABE	89D	PRL 63 1447	F. Abe *et al.*	(CDF Collab.)	REFID=40799
ABE	89J	ZPHY C45 175	K. Abe *et al.*	(VENUS Collab.)	REFID=41056
ALBAJAR	89	ZPHY C44 15	C. Albajar *et al.*	(UA1 Collab.)	REFID=40860
BARGER	89	PL B220 464	V. Barger *et al.*	(WISC, KEK)	REFID=40973
DORENBOS...	89	ZPHY C41 567	J. Dorenbosch *et al.*	(CHARM Collab.)	REFID=41055
BARTEL	87B	ZPHY C36 15	W. Bartel *et al.*	(JADE Collab.)	REFID=40455
GRIFOLS	86	PL 168B 264	J.A. Grifols, S. Peris	(BARC)	REFID=10625
JODIDIO	86	PR D34 1967	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40309
Also		PR D37 237 (erratum)	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40467
EICHTEN	84	RMP 56 579	E. Eichten *et al.*	(FNAL, LBL, OSU)	REFID=40520
RENARD	82	PL 116B 264	F.M. Renard	(CERN)	REFID=10609